Technical Memorandum

To: Souris River Joint Board
From: Mike Fogarty, Kim Smith
Subject: Closure Structure System Analysis
Date: August 13, 2024
Project: 34511010.23 MREFPP Plan Update

1 Summary

This memo documents the basis for estimating the time and resources required by the City of Minot to mobilize for and install the constructed and planned temporary closure structures and gatewells throughout the Mouse River Enhanced Flood Protection Project (MREFPP) levee alignment. Based on maximum observed daily flow increases from historical floods, the city should be prepared to install and activate all closure structures and gatewells within 5 days of flows reaching 2,500 cfs. The assumed timeline for this effort is estimated to require the following workforce and labor hour requirements:

- 940 labor hours across 5 days (including a 1.5 Safety Factor), not including trucking and off-site labor.
- At the period of highest demand, a minimum of 3 forklifts or front-end loaders and 23 laborers to be available for stoplog closure, river closure, and gatewell installation and activation.
- At the period of highest demand, a minimum of 6 side-loader trucks, 2 dump trucks, 2 loaders at material storage locations, 4 dozers, and 2 vibratory rollers, as well as 6 additional laborers for earthen closure installation.

This memo further reviews rapid installation gates as an alternate closure to stoplogs to reduce labor, time to install, and equipment requirements, and evaluates potential protection measures for closures. This memo is intended for high-level planning purposes only and is based on preliminary plans for certain structures. Closure-specific operation manuals should be consulted for specific actions required during flood events.

2 Background

The Souris River Joint Board (SRJB) is designing and constructing three levee systems (Milestone 1, 2 and 3) within the Minot Extra Territorial Area (ETA) as part of multiple phases of the MREFPP. The top elevations of the project levees are defined based on the peak flow from the flood of record (2011), accounting for risk and uncertainty and superiority. The Mouse (Souris) River at Minot has a large watershed, with significant portions regulated by reservoirs. Historically, there have been several days or more of warning for major flood events, which has given the community time to implement emergency flood measures.

The current plan for the Minot levee systems requires 19 temporary closure structures, listed in Table 1, that will need to be installed or activated in the event of a flood. Attachment A provides the location of each closure structure in the levee system. Additionally, there are 20 planned gatewells as part of the system's internal drainage infrastructure that will need to be activated in the event of a flood. Several closure structures and gatewells are still in preliminary stages, and the list of closure structures as well as specific details of the levee system may evolve as the project progresses. The levee system further includes several sewer system closures that are not considered in this analysis.

Table 1 List of Closure Structures

#[1]	Structure	Closure Type	Closure Purpose	Status
1.	Tierrecita Vallejo Railroad Closure	Temporary Earthen Closure	Railroad	Designed
2.	16th St North Road Closure	Stoplog Closure	4-Lane Road	Constructed
3.	16th St South Road Closure	Stoplog Closure	4-Lane Road	Constructed
4.	12th St SW Road Closure	Stoplog Closure	2-Lane Road	Constructed
5.	Maple Diversion Upstream River Closure Structure	Manual Head Gates	Typical River Flow	Not Designed
6.	Maple Diversion Embank Railroad Closure	Temporary Earthen Closure	Railroad	Not Designed
7.	6th St NW Road Closure	Stoplog Closure	2-Lane Road	Not Designed
8.	Maple Diversion Downstream River Closure Structure	Manual Head Gates	Typical River Flow	Not Designed
9.	Broadway Bridge Road Closure	Temporary Earthen Closure	4-Lane Roadway	Constructed
10.	Broadway Park Pedestrian Closure	Stoplog Closure	Pedestrian Trail	Constructed
11.	Anne Street Pedestrian Bridge Closure	Stoplog Closure	Pedestrian Trail	Constructed
12.	7th St NE Road Closure	Stoplog Closure	2-Lane Road	Designed
13.	12th St NE Road Closure	Stoplog Closure	2-Lane Road	Designed
14.	Roosevelt Park Pedestrian Closure	Stoplog Closure	Pedestrian Trail	Designed
15.	8th St SE West Road Closure	Stoplog Closure	2-Lane Road	Not Designed
16.	8th St SE East Road Closure	Stoplog Closure	2-Lane Road	Not Designed
17.	27th St Diversion Upstream River Closure Structure	Manual Head Gates	Typical River Flow	Not Designed
18.	27th St Diversion Downstream River Closure Structure	Manual Head Gates	Typical River Flow	Not Designed
19.	27th St North Road Closure	Stoplog Closure	2-Lane Road	Not Designed

[1] Numbering indicates the order of structures from most upstream to most downstream and is NOT indicative of order of installation.

3 Temporary Closure Installation

3.1 Flood Forecast and Preparation

During flood events, the National Weather Service publishes a 5-day flood forecast for the Mouse River USGS gage above Minot (USGS Gage 05117500). This flood forecast, along with information from the Mouse River USGS gage at Sherwood, the Des Lacs USGS gage at Foxholm, and reservoir release data from the three upstream reservoirs in Saskatchewan, is used to inform USACE emergency reservoir operations of Lake Darling and emergency response planning in Minot and neighboring communities.

The 10-year (3,000 cfs) flood event triggers the activation of the Maple Diversion River Closures and the USACE begins emergency operation of Lake Darling Dam. This analysis assumes that this flood event also triggers the activation of the 27th Street closures. Operation and installation of the temporary closure structures and gatewells are governed by the operations manual for each levee system.

3.2 Closure Mobilization and Installation Flow Triggers

Each closure structure has a flow rate that triggers the mobilization and installation of the closures. The flow triggers are listed in the operations manual and guide when certain actions should be taken for each closure. Flow triggers are based on the lowest opening elevation of a given closure and the assumed installation time required to complete the closures before floodwaters exceeding the opening elevation.

Stage discharge relationships derived from the full project (Stage 4) HEC-RAS model have been used to develop flow triggers for constructed closures. For unconstructed and undesigned closures, these rating curves were used to develop preliminary estimates for flow triggers based on available design information. Flow triggers for river closures and stoplog closure structures were estimated to be between 2,500 and 6,500 cfs, while temporary earthen closures were between 9,200 and 20,000 cfs. These established and preliminary flow triggers, in addition to site-specific considerations such as proximity and importance of closure access, were then used to determine the installation sequencing for the analysis. The assumed sequencing of installation of the temporary closure structures is provided in Attachment B.

This analysis assumes that activation of the gatewells begins simultaneously with the installation of the first closure structure at 2,500 cfs, and that activation of the gatewells occurs consecutively.

3.3 Rate of Flow Increase for Mouse River

In estimating a timetable for the engagement of the flow triggers for each structure, daily increases in flow rate from past flood events were evaluated using historic flood data from USGS gage 05117500 for the Mouse River above Minot. Data was evaluated from 1936, the construction date of the Lake Darling Dam, to present day. A maximum observed daily flow increase was determined for flood events between 2,500 cfs and 10,000 cfs for road, pedestrian, and river closures, and for flood events greater than 10,000 cfs for railroad closures. These values are listed in Table 2.

Table 2 Daily Increase of Flow Rates For Historic Flood Events

Flood Range (cfs)	Maximum Observed Daily Flow Increase (cfs)	Date of Observation
2,500 – 10,000	2,400	April 19, 1979
10,000+	12,500	June 23, 2011

The daily increase in flow rate acts as a step function, highly dependent on the reservoir operations of the Lake Darling dam. As seen in both the 2011 and 1976 floods, when flood storage is available in the reservoir the daily increase in rate of flow is observed to be lower with reservoir operations attenuating daily flow increases. However, unregulated flow from the Des Lacs River may still result in large increases in daily flow, as seen in the 1979 flood where nearly the entire 2,400 cfs increase was produced by increased flows on the Des Lacs. As flood storage becomes limited in the reservoir, dam outflows increase to match reservoir inflows and daily changes in flow rate can increase dramatically, as observed in the 2011 flood where the 12,500 cfs increase was primarily the result of increased dam outflows.

3.4 Flood Increase Timelines

Assuming a maximum daily increase in flow rate of 2,400 cfs for flood events below 10,000 cfs, the city should be prepared for the flood triggers of all river closures and stoplog closures to be engaged within 40 hours. This timeframe is particularly frontloaded, as the city should be prepared for the flow triggers for all river closures and 7 of the 12 stoplog closures to be engaged within the first 24 hours of flows reaching 2,500 cfs. It is assumed that all gatewells will need to be activated within the first 24 hours of flows reaching 2,500 cfs as well. In this timeline, there would be approximately 27 hours between the flow trigger being engaged for final stoplog closure and the flow trigger being engaged for the first temporary earthen closure at Broadway Bridge.

Limited flood storage in the Lake Darling reservoir may lead to sharp increases in flow rate shortly after flows reach 10,000 cfs, which could result in the trigger flows for the Broadway, Maple, and Tierrecita Vallejo temporary earthen closures to be engaged within a 20-hour window. The operations manuals for individual railroad closures should be consulted for specific flow triggers and timetables, along with any agreements between Canadian Pacific (CP) Rail and SRJB.

3.5 Stoplog Closure Installation Requirements

Staging and installation times for each stoplog closure were estimated based on information provided by the City regarding previous trial runs of stoplog closure installations. The following assumptions were used as part of the estimation:

- Distance between closure and material storage site

    - Assumes 16th Street and 12th Street SW closure stoplogs are stored on-site, all other stoplogs are stored at the public works building (1025 31st St SE, Minot, ND 58701).
- Transportation of stoplogs, posts, and braces
    - Assumes 68 stoplogs per pallet, separate pallets for posts and braces.
    - Pallets transported to sites via forklift or front-end loader, 1 pallet per trip.
- Number of stoplogs, posts, and braces
    - Estimated for closures that have not yet been designed
- Labor Hours & Crew Size Required
    - Assumes 0.025 labor hours per square foot at the 16th Street Closures based on trial installations by the City. Other sites range between 0.025 and 0.043 labor hours required per square foot, with increases for higher installation heights and bracing additions. Transport of materials to the site is separate from the installation.
- Equipment availability
    - Assumes all sites will require the following equipment:
    - One forklift or front-end loader equipped with forks for staging and delivery.
    - One front-end loader for post installation.
    - One or two scissor lifts for rigging removal on posts and stop log installation >8 feet. Assume two lifts are required for 8-person installation crews or larger.
- Factor of safety
    - Total estimated staging and installation time is increased by 1.5.

Table 3 lists the time and workforce needed to install each structure. The calculations for each closure are provided in Attachment C.

Table 3 Stoplog Closure Installation and Workforce Requirements

Structure	Material Staging & Installation Duration (hours)			Required Workforce (# of People)		
	Staging	Installation	Total	Laborer	Operator	Total
6th St NW Road Closure	3	7	**10**	7	1	**8**
27th St North Road Closure	1.25	3.75	**5**	7	1	**8**
12th St SW Road Closure	0	6	**0**	5	1	**6**

Structure	Material Staging & Installation Duration (hours)			Required Workforce (# of People)		
	Staging	Installation	Total	Laborer	Operator	Total
Roosevelt Park Pedestrian Closure	1	3	**4**	3	1	**4**
Anne Street Pedestrian Bridge Closure	1	2	**3**	3	1	**4**
8th St SE East Road Closure	1.5	5.5	**7**	5	1	**6**
12th St NE Road Closure	1.5	4.5	**6**	3	1	**4**
Broadway Park Pedestrian Closure	2	5	**7**	7	1	**8**
7th St NE Road Closure	2.5	4.5	**7**	7	1	**8**
8th St SE West Road Closure	2	6	**8**	3	1	**4**
16th St North Road Closure	0	6	**6**	7	1	**8**
16th St South Road Closure	0	6	**6**	7	1	**8**

3.6 River Closure Structure Activation Requirements

Little information was provided regarding the requirements for activating the four river closure structures in the system (Maple Diversion Upstream/Downstream, 27th Street Diversion Upstream/Downstream). It was assumed that all necessary equipment for head gate operation was available on-site or able to be provided by those operating the gates. It was assumed that each gate would require 2 laborers and approximately 1.5 hours to travel to and activate each closure.

3.7 Temporary Earthen Closure Installation Requirements

High-level estimates for the installation times of the Tierrecita Vallejo and Maple Diversion temporary earthen railroad closures were documented in the Barr memo dated June 7, 2022. A similar estimate for the installation time of the Broadway Bridge temporary earthen closure is provided in the operations memo by Houston Engineering, Inc. dated April 29, 2022.

These previous estimates were used as a general basis for this analysis, however updates to several base assumptions such as loading and transportation time, backfilling, and compaction were made based on data available through RSMeans. The two methods produced similar results. The following parameters were used for the updated estimate:

- Track removal and base prep
  - 2 hours to remove railroad tracks and prepare base, assumed to be completed by CP Rail
- Hauling capacity

  - 12 cubic yard (CY) truck capacity for locally stored materials and 18 CY side-loader trucks for materials stored offsite
  - 2-6 trucks available per site
  - 1 Loader at material storage location
- Location of borrow source
  - Assumes soil is stockpiled adjacent to closure for Tierrecita Vallejo, and off site for all other closures
- Backfilling
  - 0.005 labor hours per loose cubic yard of soil, per RSMeans
  - One to two dozers with operators and 1-2 laborers on site
- Compaction frequency and duration
  - 0.002 labor hours per compacted cubic yard of soil, per RSMeans
  - 1 12-ton vibratory roller with operator and 1 laborer on site
- Cover installation for erosion protection
  - 2 hours to install earthen closure cover (plastic, sandbags)
- Factor of safety
  - Total estimated installation time is 1.5 times the sum of the transportation, backfill, compaction, and cover times

The estimated installation times for each earthen closure are provided in Table 4. The calculations for each earthen closure are provided in Attachment D.

Table 4 Temporary Earthen Closure Installation and Workforce Requirements

Structure	Required Installation Time (hours)	Workforce Required			
		Laborer	Operator	Driver	Total
Broadway Bridge Road Closure	9 hours	3	4	4	**11**
Maple Diversion Embank Railroad Closure[1]	22 hours (Phase 1) 8 hours (Phase 2) 13 hours (Phase 3)	3	4	6	**13**
Tierrecita Vallejo Railroad Closure	12 hours	3	4	2	**9**

[1] Maple Diversion Embank Railroad Closure is planned to be constructed in three phases with unique flow triggers. Consult the operations manual for a specific definition of each phase

3.8 Gatewell Installation Requirements

Little information was provided regarding the requirements for activating the gatewells. It was assumed that all necessary equipment for gatewell operation was available on-site or able to be provided by those operating the gates. It was assumed that each gate would require 2 laborers and approximately 1.5 hours to travel to and activate each gatewell. Therefore with 2 laborers, it estimated that activation of all 20 gatewells would take 30 hours. Separate 2-person crews would likely then be necessary to complete activation of the gatewells within 24-hours of floods reaching 2,500 cfs.

3.9 Closure System Installation Timeline

Based on the installation estimates provided in Sections 3.5, 3.6, and 3.7, a theoretical installation timeline for the entire network of closures and gatewells was developed. This timeline is represented by a Gantt chart provided in Attachment E. The timeline assumes that no closure structure begins installation before reaching its estimated flow trigger, and that installation work for the closures and gatewells is continuous, regardless of time of day, once the initial flow trigger is reached. It's estimated that 940 labor hours would be required to meet the 5-day timeline laid out in the Gantt Chart, not including trucking and other labor occurring off-site.

For stoplog installation, the period of highest demand for labor and equipment occurs during the installations of the 6th St NW, North 27th St, and 12th St NW road closures, which need to be installed simultaneously to ensure installation is completed before the engagement of the river closure structures. This would require a minimum of 3 forklifts or front-end loaders and 19 laborers to be available between the three closures. Furthermore, it is also assumed that the installation of these stoplog closures occurs simultaneously with the activation of the gatewells, which would require an additional 4 laborers. Pending the final design and opening elevation for the three closures, a more proactive flow trigger may be required to ensure installation of the closures does not delay engagement of the river closure structures. Based on the 2,400 cfs maximum rate of flow increase discussed in Section 2.3, it's estimated that for the remaining stoplog closures there is sufficient time between flow trigger and flow overtopping the minimum opening elevation for the structures to be installed in succession.

The railroad closures each have flow triggers at or above 10,000 cfs and are therefore more susceptible to rapid rates of flow increase seen in the 2011 flood. Therefore, the City should maintain sufficient labor and equipment capacity to conduct the installation of the railroad closures simultaneously. Simultaneous installation of the Maple and Tierrecita Vallejo Railroad Closures would require 6 side-loader trucks, 2 dump trucks, 2 loaders at material storage locations, 4 dozers, and 2 vibratory rollers, as well as 6 additional laborers. Additionally, the estimates provided in Section 2.7 don't assume that material for all closures is stockpiled at a common site, and additional time for material loading may be required if a common storage site is unable to keep pace with the material needed for multiple earth closures simultaneously. The estimates find that current flow triggers for both Tierrecita Vallejo and Maple provide insufficient time to complete installation prior to floodwater reaching the base of the closure's opening under the maximum flow increases seen in the 2011 flood. If additional equipment or trucks can be provided above what is noted in Section 2.7, installation times for each closure may be reduced.

4 Alternative Closure Considerations

Most temporary closures in the North Minot system use stoplogs, which are time and labor-intensive to install. Using rapid installation gates, such as roller/slide gates, are an option for wide roadway closures. Swing gates are an option at narrower closures such as for pedestrian crossings.

Roller/slide gates would be permanent installations that ride on guide tracks running parallel to the floodwall or levee. They require minimal labor and time to install. Rapid installation gates are more expensive to build than stoplog closures and require a higher level of upkeep and maintenance. Table 5 compares the cost, installation time, and labor requirements of roller/slide gates and stoplogs for select structures. A manufacturer with experience fabricating both roller/slide gates and stoplogs provided the costs and labor estimates. Costs reflect new construction, however, stoplog closures can be retrofitted to accommodate slide gates.

Table 5 Stoplog and Slide Gate Cost, Time, and Labor Comparison

	7th St NE Road Closure	8th St SE Road (West and East) Closures	27th St North Road Closure
Dimensions	64 ft (W) x 12.5 ft (H)	60 ft (W) x 9 ft (H)	52 ft (W) x 12.1 ft (H)
Stoplog Cost[1]	$190,000	$130,000	$140,000
Stoplog Installation Time	5.75 hours	6.5 hours	4.75 hours
Stoplog Workforce Required	Total: 9 Driver: 1 Operator: 1 Laborer: 7	Total: 5 Driver: 1 Operator: 1 Laborer: 3	Total: 9 Driver: 1 Operator: 1 Laborer: 7
Roller/Slide Gate Cost[1]	$1,350,000	$920,000	$1,050,000
Roller/Slide Gate Installation Time	<1 hour	<1 hour	<1 hour
Roller/Slide Gate Labor	<3 Laborers	<3 Laborers	<3 Laborers

[1]Costs are high-level estimates that vary depending on time, location, and specific circumstances of project

Slide gates provide the greatest benefit at road closures where the time required for installation is highest. The quick installation would allow for higher flow triggers and allow roadways to remain open longer. This would free up staff and equipment for use elsewhere. Using a slide gate for the 27th St North Road Closure, for example, would allow the roadway to remain open until it is time to close the gates on the river closure structures to activate the 27th Street diversion.

5 Stoplog Closure Protection

The stoplog closures are typically located on or adjacent to active roadways. Barriers and other protection measures are recommended to reduce the risk of vehicular impacts damaging closure components. The level of protection desired at a given closure would depend on the potential for the closure to be struck. Roadway closures with high traffic volumes, higher speed limits, or poor visibility are at greater risk of vehicle collisions and warrant more robust protection measures. Potential protection measures for consideration are discussed below. Table 6 lists the estimated cost and installation time for different types of barriers.

Table 6 Closure Protection Comparison

Structure	Cost Per Road Closure[1]	Cost Per Pedestrian Closure[1]	Required Workforce To Install	Protection Level
Pedestrian Barricades	$5,000	$2,000	Two laborers, truck and trailer	Low
Type III Barricades	$3,000	$1,000	Two laborers, truck and trailer	Low
Concrete Jersey Barriers	$5,000	$2,000	Two laborers, truck, trailer, loader/skid steer	High
Water Filled Barriers	$5,000	$2,000	Two laborers, truck and trailer, water supply	High
Removeable Bollards	$81,000	$22,000	Two laborers and truck	High

[1]Costs are high-level estimates that vary depending on time, location, and specific circumstances of project. Costs presented assume widths of 88' and 24' for road and pedestrian closures respectively.

5.1 Pedestrian Barricades

ADA pedestrian barricades, shown in Figure 1, are recommended for low-risk pedestrian closures. ADA barricades are made of a plastic material and are relatively light and mobile. The barricades can be secured down with sandbags. Although they would not significantly impede vehicle collisions, they would deter pedestrians from accessing the stoplogs and delineate the working area during closure installation. The barricades could be deployed quickly by two or more workers and a truck or truck and trailer.

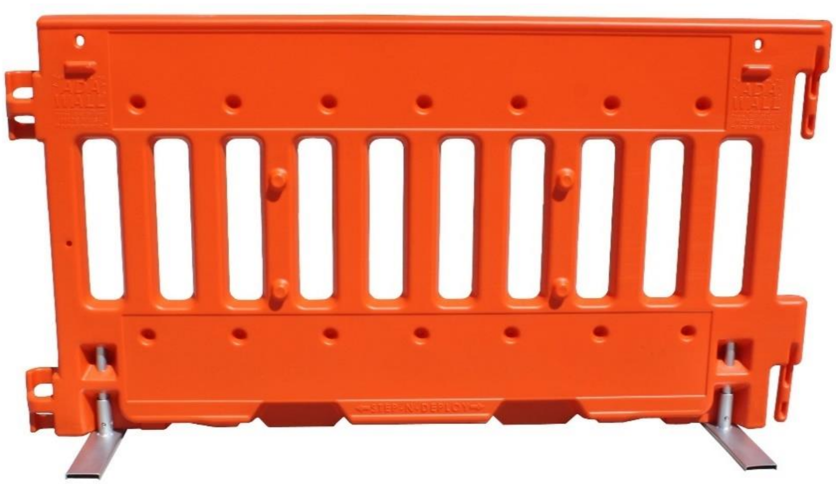

Figure 1 Pedestrian Barricade Example

5.2 Type III Barricades

Type III barricades, shown in Figure 2, are recommended for pedestrian closures and low-risk roadways. Type III barricades are a standard road closure barrier, designed to have high visibility for oncoming traffic. Type III barricades provide little to no physical protection from vehicular collisions but would deter traffic from approaching closure. The barricades are easily accessible for the City and could be deployed by two or more workers with a truck or truck and trailer.

Figure 2 Type III Barricade Example

5.3 Concrete Jersey Barriers

Concrete jersey barriers, shown in Figure 3, are an option for high-risk roadways. Jersey barrier weights can range from several hundred to several thousand pounds. They provide a physical barrier to prevent vehicles from colliding with the closure. Jersey barriers are easily accessible to the City. Installation would be more time-consuming than lighter barricades. Installation would require a truck, trailer, and front-end loader or forklift.

Figure 3 Concrete Jersey Barrier Example

5.4 Water-Filled Barriers

Water-filled barriers, shown in Figure 4, are an option for high-risk roadways, offering similar stopping power to concrete jersey barriers. Water-filled barriers are designed to be more visible and are generally safer for motorists involved in a collision due to more effective shock absorption. Water-filled barriers would require more space for installation than concrete jersey barriers because they are wider and should be installed further from the closure to deflect and move to absorb vehicle impacts. Water-filled barriers would not likely require heavy equipment to deliver to the closure site. Installation time is longer than for concrete jersey barriers because of the time and resources needed to fill the barriers with water. A water truck or local water source would be required.

Figure 4 Water-Filled Barriers Example

5.5 Removeable Bollards

Removable bollards, shown in Figure 5, are option for high-risk roadways. Bollards come in a wide range of impact ratings. Bollards would allow for rapid installation without the need for heavy equipment. Bollards require special footings that would be installed during the project construction. Bollards require occasional maintenance to prevent deterioration of the connection between the bollard and footing. Bollards are less visible than water-filled barriers, however, they could be paired with type III barriers for visibility. Bollards would likely require custom order and installation. Installation would require a truck and two laborers to install at a minimum.

Figure 5 Temporary Bollards Example

6 Closure Structure System Analysis Conclusion

This memo documents the basis for estimating the time and resources required for the City of Minot to mobilize for and install temporary closure structures and gatewells in its MREFPP levee systems. Barr reviewed rapid installation gate closures to reduce labor, installation time, and equipment requirements, and evaluated potential protection measures for closures. The information provided here is intended for planning purposes only and is based on preliminary plans for certain structures. Closure-specific operation manuals should be developed and consulted for specific actions required during flood events.

Based on maximum observed daily flow increases from historical floods, the city should be prepared to install and activate all closure structures and gatewells within 5 days of flows reaching 2,500 cfs. The assumed timeline for this effort is estimated to require the following workforce and labor hour requirements:

- 940 labor hours across 5 days (including a 1.5 Safety Factor), not including trucking and off-site labor.
- At the period of highest demand, a minimum of 3 forklifts or front-end loaders and 23 laborers to be available for stoplog closure, river closure structure, and gatewell installation and activation.
- At the period of highest demand, a minimum of 6 side-loader trucks, 2 dump trucks, 2 loaders at material storage locations, 4 dozers, and 2 vibratory rollers, as well as 6 additional laborers for earthen closure installation.

The period of highest demand for labor and equipment for stoplog closure installations occurs when the river closure structures are planned to be engaged, requiring the simultaneous installation of 6th Street NW, North 27th Street, and 12th St NW road closures in addition to the activation of the gatewells. The City may want to consider the select use of rapid installation gates at these locations to reduce peak demand for labor and equipment, however these gates would come at a higher cost compared to stoplogs.

Demand for labor and equipment increases further during the installation of the temporary earthen closures, whose high flow trigger make them more susceptible to rapid increases in flow, necessitating simultaneous installation. The actual timeline, required labor, and equipment needed for installation will depend on the unique circumstances of a given flood, along with the coordinated efforts between SRJB, the City, CP Rail, and the US Army Corps of Engineers. The City should ensure sufficient labor and equipment capacity is available to allow installation of the earthen closures to be completed prior to flood levels exceeding the base of each closure.

Barriers and other protection measures are recommended at stoplog closures to reduce the risk of vehicular impacts damaging closure components. The level of protection desired at a given closure would depend on estimated risk to each closure. Roadway closures with high traffic volumes, higher speed limits, or poor visibility are at greater risk of vehicle collisions and warrant more robust protection measures.

Attachments

Attachment A Closure System Layout
Attachment B Temporary Closure Installation Sequencing
Attachment C Stoplog Closure Installation Time Calculations
Attachment D Temporary Earthen Closure Installation Time Calculations
Attachment E Closure Installation Gantt Chart

Attachments

Attachment A

Closure System Layout

Closure Structure

Storage Location

Levee Footprint

Note: Intent of map is to identify the approximate locations of closures currently constructed or planned for the levee system. Closures may be added, removed, or relocated as project progresses.

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Feet

Imagery Source: NearMap (2023)

Preliminary Closure and Storage Locations

MREFPP
Minot, ND

FIGURE 1

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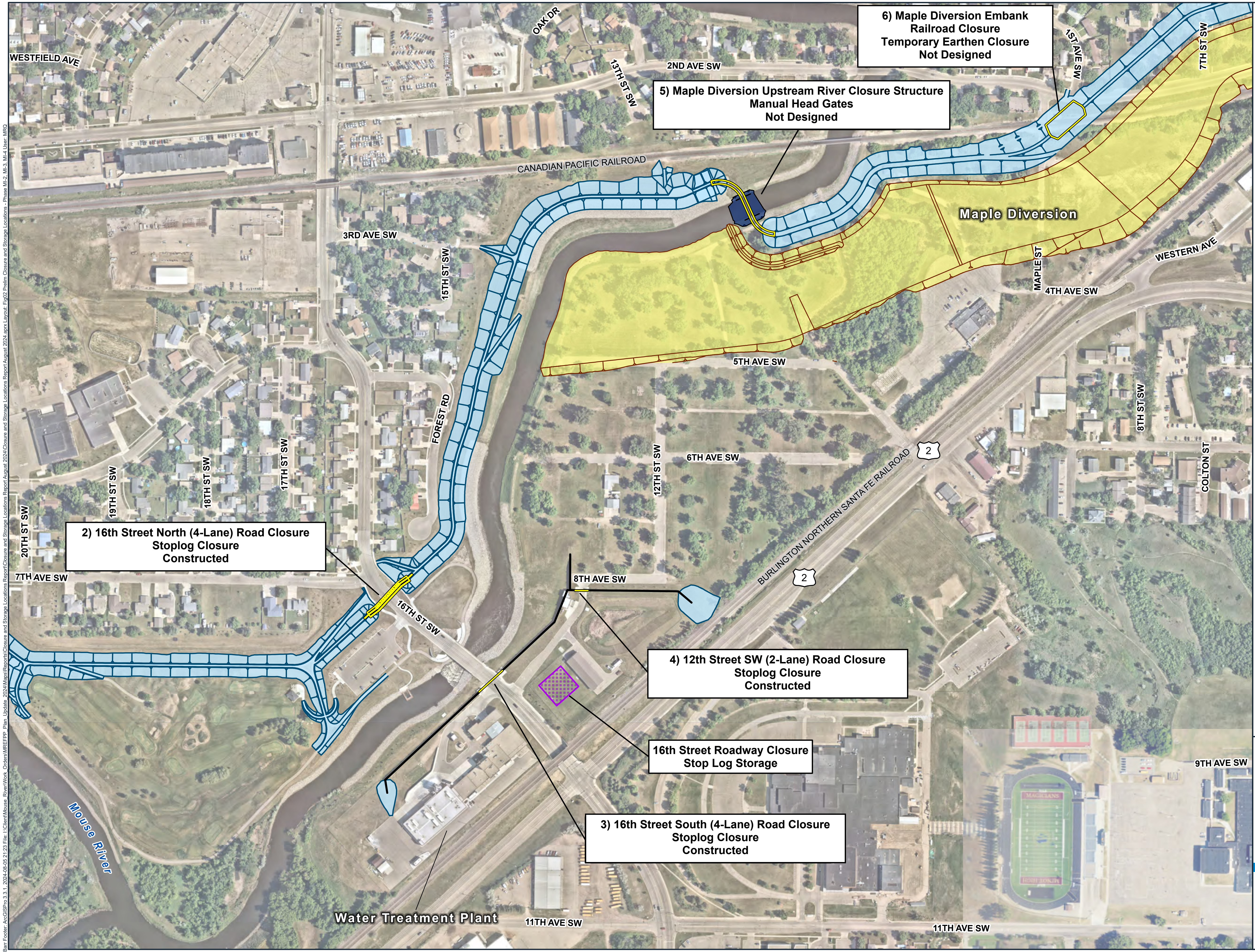

Closure Structure
Floodwall
Storage Location
Levee Footprint
High Flow Diversion
River Closure Area

Note: Intent of map is to identify the approximate locations of closures currently constructed or planned for the levee system. Closures may be added, removed, or relocated as project progresses.

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Imagery Source: NearMap (2023) and USDA NAIP (2023)

Preliminary Closure and Storage Locations

MREFPP
Minot, ND

FIGURE 2

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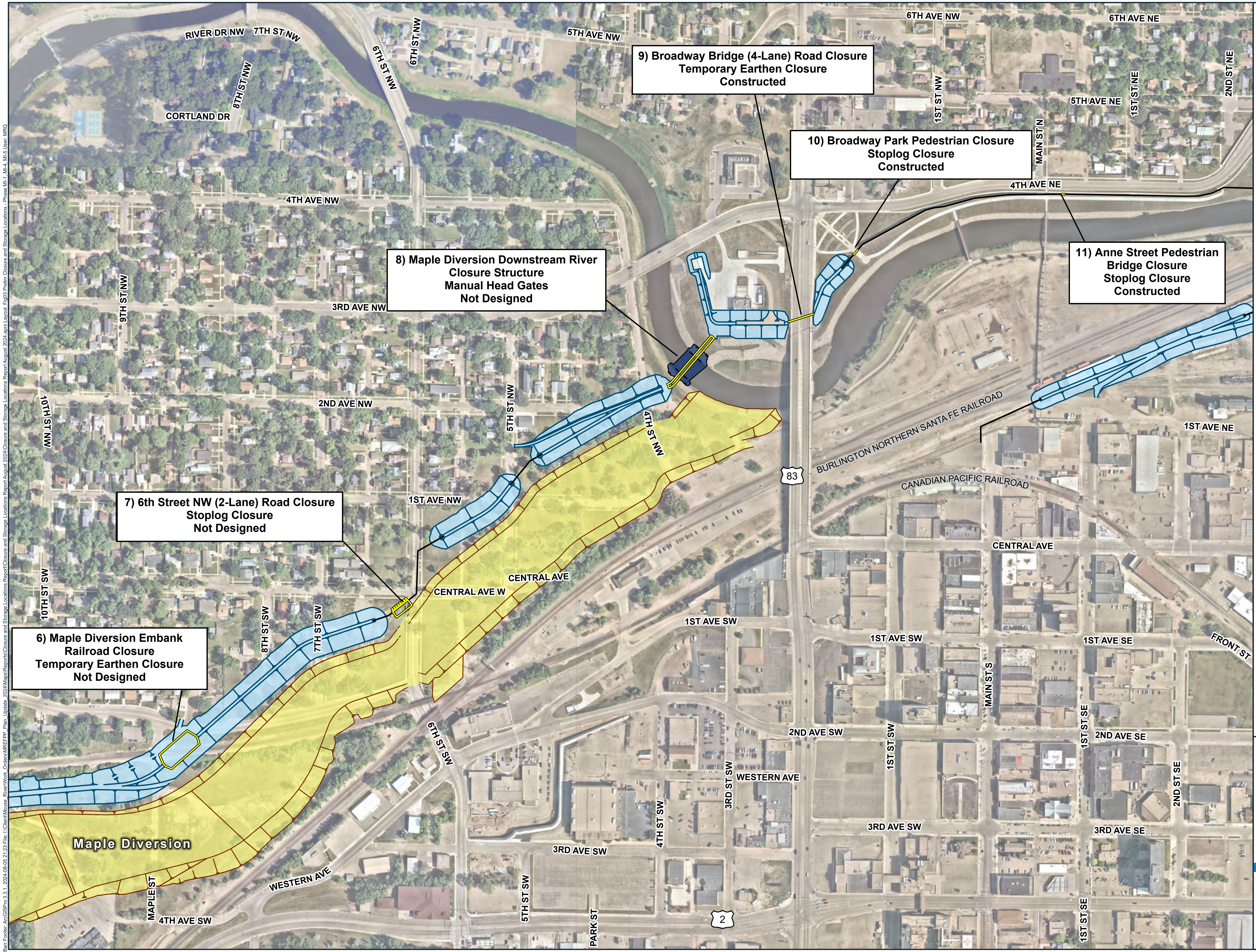

Closure Structure

Floodwall

Levee Footprint

High Flow Diversion

River Closure Area

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Imagery Source: NearMap (2023) and USDA NAIP (2023)

Preliminary Closure and Storage Locations

MREFPP
Minot, ND

FIGURE 3

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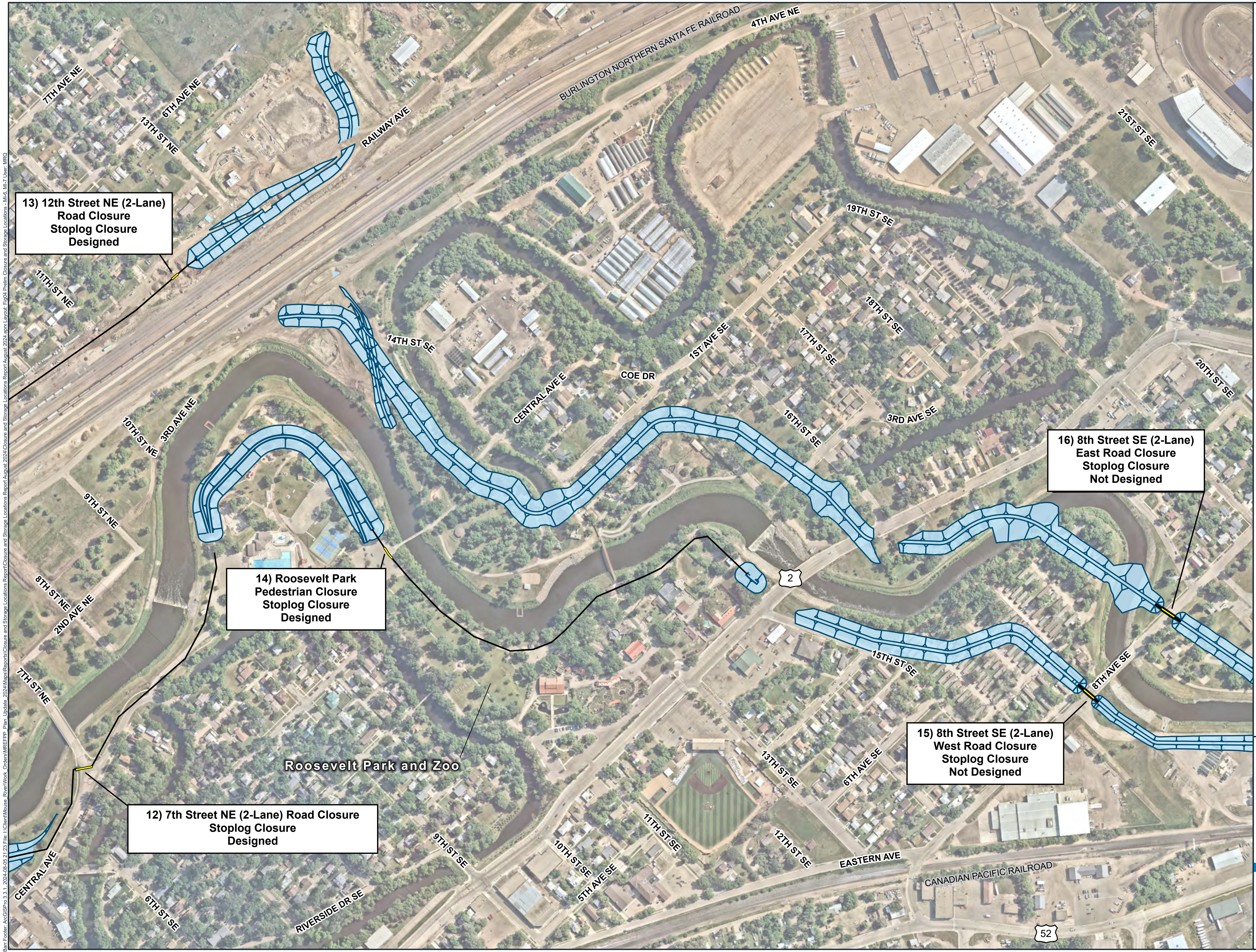

Closure Structure

Floodwall

Levee Footprint

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Imagery Source: NearMap (2023) and USDA NAIP (2023)

Preliminary Closure and Storage Locations

MREFPP
Minot, ND

FIGURE 4

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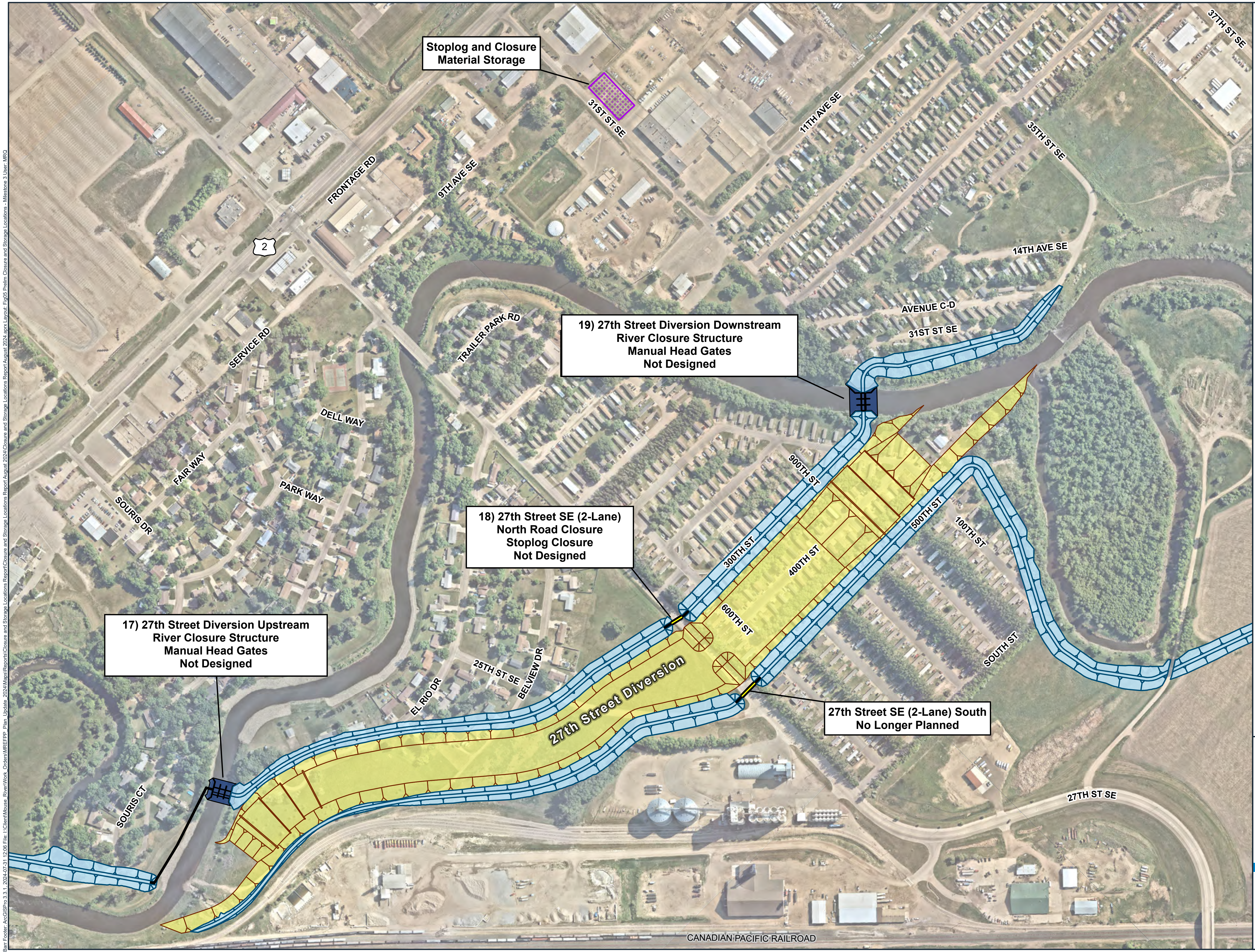

- Closure Structure
- Floodwall
- Storage Location
- Levee Footprint
- High Flow Diversion
- River Closure Area

Note: Intent of map is to identify the approximate locations of closures currently constructed or planned for the levee system. Closures may be added, removed, or relocated as project progresses.

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Feet

Imagery Source: NearMap (2023) and USDA NAIP (2023)

Preliminary Closure and Storage Locations

MREFPP
Minot, ND

FIGURE 5

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ACKERMAN ESTVOLD

Attachment B

Temporary Closure Installation Sequencing

Structure	Closure Type	Preliminary Trigger Flow
6th St NW Road Closure[1 2]	Stoplog Closure	2,500
27th St North Road Closure[1 2]	Stoplog Closure	2,500
12th St SW Road Closure[1]	Stoplog Closure	2,500
Roosevelt Park Pedestrian Closure	Stoplog Closure	2,500
Anne Street Pedestrian Bridge Closure	Stoplog Closure	2,500
Maple Diversion Upstream River Closure Structure[2]	Manual Head Gates	3,000
Maple Diversion Upstream River Closure Structure[2]	Manual Head Gates	3,000
27th St Diversion Upstream River Closure Structure[2]	Manual Head Gates	3,000
27th St Diversion Upstream River Closure Structure[2]	Manual Head Gates	3,000
8th St SE East Road Closure[2]	Stoplog Closure	3,000
12th St NE Road Closure	Stoplog Closure	3,000
Broadway Park Pedestrian Closure	Stoplog Closure	4,000
7th St NE Road Closure	Stoplog Closure	5,000
8th St SE West Road Closure[2]	Stoplog Closure	6,500
16th St North Road Closure	Stoplog Closure	6,500
16th St South Road Closure	Stoplog Closure	6,500
Broadway Bridge Road Closure	Temporary Earthen Levee	9,200
Maple Diversion Embank Railroad Closure[2]	Temporary Earthen Levee	10,000, 14,000, 20,000[3]
Tierrecita Vallejo Railroad Closure	Temporary Earthen Levee	14,000

[1] Flows quickly overtop closure openings once river closures are engaged. Installation must be completed prior to engagement of river closures to prevent overtopping.

[2] Limited design information on freeboard elevation, preliminary estimate only.

[3] Multiphase installations, see operations manual for more information.

Attachment C

Stoplog Closure Installation Time Calculations

Attachment C

Stoplog Closure Staging and Installation Estimate Example Calc[1]

6th St NW Road Closure

Mouse (Souris) River at Minot, ND

Time 1 = Staging (Load and Transport of Closure Materials)			
# Stoplog Bays	6	#	
Stoplogs Per Bay	33	#	
Total Number of Stoplogs	198	#	
Pallets Required For Stoplogs	3	#	68 Stoplogs Per Pallet
Total Number of Posts	5	#	
Braces Required	Yes		
Pallets Required For Posts and Braces	3	#	4 Posts Per Pallet, 1 Pallet for All Braces
Total Pallets Required	6	#	
Distance to Storage Area	3.6 (9)	miles (min)	
Round Trip Time To Storage Area	20	min	Assume 1 Pallet Per Trip
Staging Time (T1) =	**2**	hrs	= Total Pallets x Round Trip Time
Time 2 = Installation			
Closure Width	50	ft	Maximum closure height
Closure Height	21.6	ft	
Closure Area	1080	sf	
Production Rate	0.036	Labor Hours/ Square Foot	Assumption based on previous trial installation by city, varies based on height of closure and addition of braces (0.028 if Height < 11 ft, 0.033 if 11 ft < Height < 17 ft, 0.036 if Height > 17 ft)
Total Labor Hours	38.9	hrs	
Crew Size	8		Including Laborers and Operators
Installation Time (T2) =	4.9	hrs	=Installation Hours / Crew Size
Total			
Installation +Staging Time (min)	6.9	hrs	= T1+T2
Factor of Safety	150%	%	
Phase Installation Times =	**10**	**hrs**	= Factor of Safety x Installation Time

Notes

Inputs

1 - Assumes all equipment mobilized to site

Location	Time Factor of Safety	Closure Width (ft)	Height (ft)	Area of Closure (ft^2)	Production Rate LH/SF	Installation Labor Hours	# in Crew	Installation Time (hrs)	# of Bays and Stoplogs/Bay	# Total Stoplogs	# Posts	Pallets Required For Stoplogs	Pallets for Posts and Braces	# Pallets Total	Distance to Storage Area (mi)	RT Time To Storage Area (min)	Pallet & Post Transport Time (hrs)	Factored Installation + Staging Time (hrs)
6th St NW Road Closure	1.5	50	21.6	1080	0.036	38.9	8	4.9	6 Bay x 33 logs high	198	5 w/ braces	3	3	6	3.6 (9 min)	20	2	10
27th St North Embank Road Closure	1.5	52	12.1	629	0.033	20.8	8	2.6	6 bay x 19 logs high	114	5 w/ braces	2	3	5	1 mi (3 min)	10	0.83	5
12th St SW Road Closure	1.5	47.5	16.5	784	0.033	25.9	6	4.3	6 Bays x 25 logs high	150	5 w/ braces	3	3	6	On Site	n/a	0	6
Roosevelt Park Pedestrian Closure	1.5	16.33	15	245	0.033	8.1	4	2.0	2 bay x 23 logs high	46	1 w/ braces	1	1	2	2.9 (8 min)	20	0.67	4
Anne Street Pedestrian Bridge Closure	1.5	10	13.5	135	0.033	4.5	4	1.1	1 Bay x 21 log high	21	1 (Assume)	1	1	2	3.3 (8 min)	20	0.67	3
8th St SE East Road Closure	1.5	60	11.3	678	0.033	22.4	6	3.7	8 bays x 15 logs high	120	7 w/ braces	2	3	5	1.2 (5 min)	10	0.83	7
12th St NE Road Closure	1.5	24.5	14.4	353	0.033	11.6	4	2.9	3 bays x 22 logs high	66	2 w/ braces	1	2	3	3.2 (8 min)	20	1.00	6
Broadway Park Pedestrian Closure	1.5	24 (Main) 16 (Sides Ea.)	13.5 (Main) 10 (Sides)	644	0.042	27.0	8	3.4	3 Bay x 21 logs high (Main) 2 Bay x 16 logs high (Sides)	127	4 w/ braces	2	2	4	3.5 (8 min)	20	1.33	7
7th St NE Road Closure	1.5	64	12.5	800	0.033	26.4	8	3.3	8 Bay x 19 log high	133	6 w/ braces	2	3	5	2.5 (7 min)	20	1.67	7
8th St SE West Road Closure	1.5	60	9	540	0.028	15.1	4	3.8	8 bays x 14 logs high	112	7	2	3	5	2 (6 min)	15	1.25	8
16th St North Road Closure	1.5	87.17 (Main) 15.17 (Sides Ea.)	9.76	1147	0.028	32.0	8	4.0	11 bays x 15 logs high (Main) 2 bay x 16 logs high (Sides)	225	12	4	3	7	On Site	n/a	0	6
16th St South Road Closure	1.5	87.5 (Main) 15.5 (Sides Ea.)	10.33	1224	0.028	32.0	8	4.0	11 bays x 16 logs high (Main) 2 bay x 16 logs high (Sides)	240	12	4	3	7	On Site	n/a	0	6

Based on Previous Trial Runs By City

Increased Due to Unique Site Layout

Attachment D

Temporary Earthen Closure Installation Time Calculations

Attachment D-1
Earthen Closure Time to Install Estimate[1]
Roadway Closure at Broadway Bridge
Mouse (Souris) River at Minot, ND

Description	Value	Units	Comments
Closure Height	5.5	ft	Maximum closure height
Compacted Volume (CV)	600	cy	
Volume Conversion	130%	%	Loose Volume / Compacted Volume
Loose Volume (LV)	800	cy	= Volume conversion*CV
Time 1 = Load and Transport Soil from Borrow Area			
Truck Capacity	18	cy	Volume, Side Dump Truck
Trucks	4	#	number of trucks
Cycle Time	20	min	Time for Loading, Travel, Offloading, and Return
Truckloads	45	#	= LV/Truck Capacity
T1 =	3.75	hrs	= (Truck Loads*Cycle Time)/# of Trucks
Time 2 = Backfilling			
Labor Hours Per Cubic Yard	0.005	LH/LCY	RSMeans Data, backfilling common earth w/ 200 HP Dozer and 0.5 Laborer per labor unit
Labor Units	2	#	Assume 2 Dozers and 2 Laborers
T2 =	2	hrs	=(LV*Labor Hours Per Cubic Yard)/Labor Units
Time 3 = Compaction			
Labor Hours Per Cubic Yard	0.002	LH/BCY	RSMeans Data, compacting with 1 12 ton vibratory roller and 0.5 laborer per labor unit, 12" lifts with 2 passes
Labor Units	1	#	Assume 1 Compactor and 1 Laborer
T3 =	1.2	hrs	=(CV*Labor Hours Per Cubic Yard)/Labor Units
Time 4 = Levee Cover/Protection			
T4 =	2	hrs	Install time for plastic, sand bags, etc.
Summary			
Total Installation Time	6	hrs	= max(T1,T2+T3)+T4
Factor of Safety	150%	%	
Phase Installation Times =	**9**	**hrs**	= Factor of Safety*Installation Time

Notes

Inputs

1 - Assumes all equipment mobilized to site

2 - Assumes borrow material is stockpiled within 5 miles of site

Attachment D-2
Earthen Closure Time to Install Estimate[1]
CP Rail Closure at Maple Diversion
Mouse (Souris) River at Minot, ND

	Closure Installation Phases				
Description	**Phase 1**	**Phase 2**	**Phase 3**	**Units**	**Comments**
Closure Height	4.3	4.3	3	ft	Maximum closure height
Compacted Volume (CV)	2340	320	1200	cy	
Volume Conversion	130%	130%	130%	%	Loose Volume / Compacted Volume
Loose Volume (LV)	3100	500	1600	cy	= Volume conversion*CV
			5200		
Time 1 = Track Removal and Base Prep					
T1 =	0	2	0	hrs	CP Rail
Time 2 = Load and Transport Soil from Borrow Area					
Truck Capacity	18	18	18	cy	Volume, Side Dump Trucks
Trucks	6	5	6	#	number of trucks
Cycle Time	20	20	20	min	Time for Loading, Travel, Offloading, and Return
Truckloads	173	28	89	#	= LV/Truck Capacity
T2 =	9.6	1.9	5.0	hrs	= (Truck Loads*Cycle Time)/# of Trucks
Time 3 = Backfilling					
Labor Hours Per Cubic Yard	0.005	0.005	0.005	LH/LCY	RSMeans Data, backfilling common earth w/ 200 HP Dozer and 0.5 Laborer per labor unit
Labor Units	2	2	2	#	Assume 2 Dozers and 2 Laborers
T3 =	7.75	1.25	4	hrs	=(LV*Labor Hours Per Cubic Yard)/Labor Units
Time 4 = Compaction					
Labor Hours Per Cubic Yard	0.002	0.002	0.002	LH/BCY	RSMeans Data, compacting with 1 12 ton vibratory roller and 0.5 laborer per labor unit, 12" lifts with 2 passes
Labor Units	1	1	1	#	Assume 1 Compactor and 1 Laborer
T4 =	4.68	0.64	2.4	hrs	=(CV*Labor Hours Per Cubic Yard)/Labor Units
Time 5 = Levee Cover/Protection					
T5 =	2	1	2	hrs	Install time for plastic, sand bags, etc.
Summary					
Installation Time	14	5	8	hrs	= T1+max(T2,T3+T4)+T5
Factor of Safety	150%	150%	150%	%	
Phase Installation Times =	**22**	**8**	**13**	**hrs**	= Factor of Safety*Installation Time

Notes

Inputs

1 - Assumes all equipment mobilized to site

2 - Assumes borrow material is stockpiled within 5 miles of site

Attachment D-3

Earthen Closure Time to Install Estimate[1]

CP Rail Closure at Tierrecita Vallejo

Mouse (Souris) River at Minot, ND

Description	**Value**	**Units**	**Comments**
Closure Height	6.3	ft	Maximum closure height
Compacted Volume (CV)	690	cy	
Volume Conversion	130%	%	Loose Volume / Compacted Volume
Loose Volume (LV)	900	cy	= Volume conversion*CV
Time 1 = Track Removal and Base Prep			
T1 =	2	hrs	CP Rail
Time 2 = Load and Transport Soil from Borrow Area			
Truck Capacity	12	cy	Volume, Dump Trucks
Trucks	2	#	number of trucks
Cycle Time	5	min	Time for Loading, Travel, Offloading, and Return[2]
Truckloads	75	#	= LV/Truck Capacity
T2 =	3.13	hrs	= (Truck Loads*Cycle Time)/# of Trucks
Time 3 = Backfilling			
Labor Hours Per Cubic Yard	0.005	LH/LCY	RSMeans Data, backfilling common earth w/ 200 HP Dozer and 0.5 Laborer per labor unit
Labor Units	2	#	Assume 2 Dozers and 2 Laborers
T3 =	2.25	hrs	=(LV*Labor Hours Per Cubic Yard)/Labor Units
Time 4 = Compaction			
Labor Hours Per Cubic Yard	0.002	LH/BCY	RSMeans Data, compacting with 1 12 ton vibratory roller and 0.5 laborer per labor unit, 12" lifts with 2 passes
Labor Units	1	#	Assume 1 Compactor and 1 Laborer
T4 =	1.38	hrs	=(CV*Labor Hours Per Cubic Yard)/Labor Units
Time 5 = Levee Cover/Protection			
T5 =	2	hrs	Install time for plastic, sand bags, etc.
Summary			
Total Installation Time	8	hrs	= T1+max(T2,T3+T4)+T5
Factor of Safety	150%	%	
Phase Installation Times =	**12**	**hrs**	= Factor of Safety*Installation Time

Notes

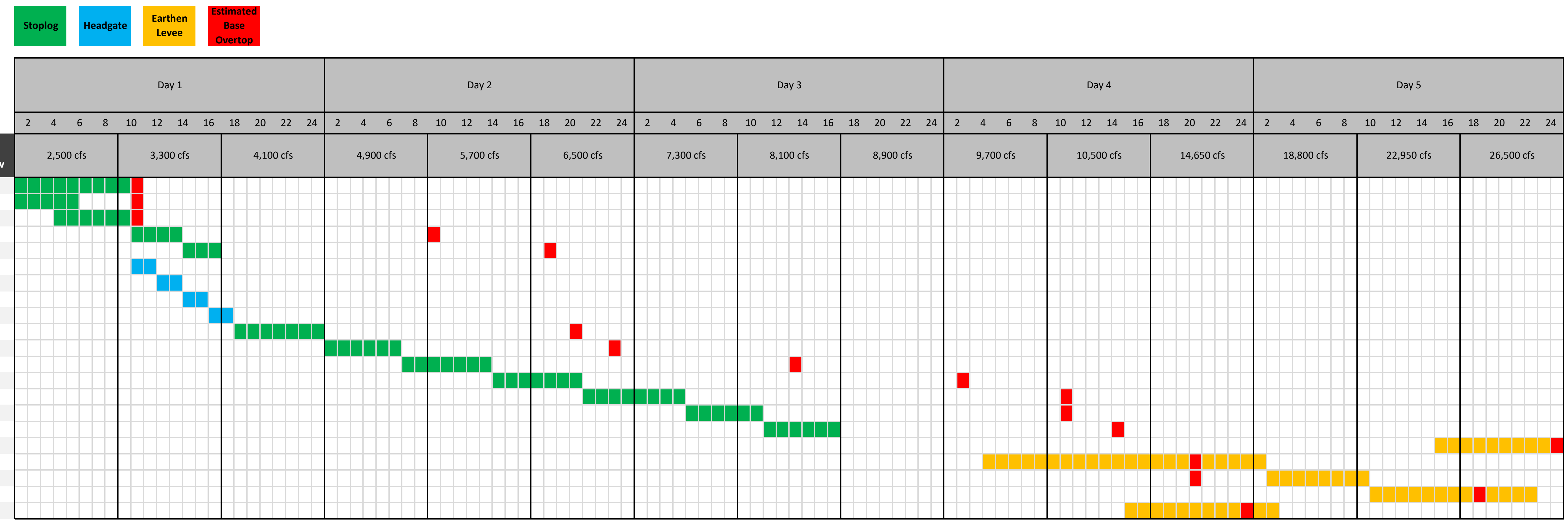
Inputs

1 - Assumes all equipment mobilized to site

2 - Assumes borrow material is stockpiled adjacent to closure

Attachment E

Closure Installation Gantt Chart



Closure Structure	Estimated Trigger Flow
6th St NW Road Closure	2500
27th St North Road Closure	2500
12th St SW Road Closure	2500
Roosevelt Park Pedestrian Closure	2500
Anne Street Pedestrian Bridge Closure	2500
Maple Diversion Upstream River Closure Structure	3000
Maple Diversion Downstream River Closure Structure	3000
27th St Diversion Upstream River Closure Structure	3000
27th St Diversion Downstream River Closure Structure	3000
8th St SE East Road Closure	3000
12th St NE Road Closure	3000
Broadway Park Pedestrian Closure	4000
7th St NE Road Closure	5000
8th St SE West Roadway Closure	6500
16th St North Road Closure	6500
16th St South Road Closure	6500
Broadway Bridge Road Closure (1)	9200
Maple Diversion Embank Railroad Closure, Phase 1	10000
Maple Diversion Embank Railroad Closure, Phase 2	10000
Maple Diversion Embank Railroad Closure, Phase 3	20000
Tierrecita Vallejo Railroad Closure	14000

(1) - Installation of closure based on flood forecast as defined in the North Minot O&M Manual